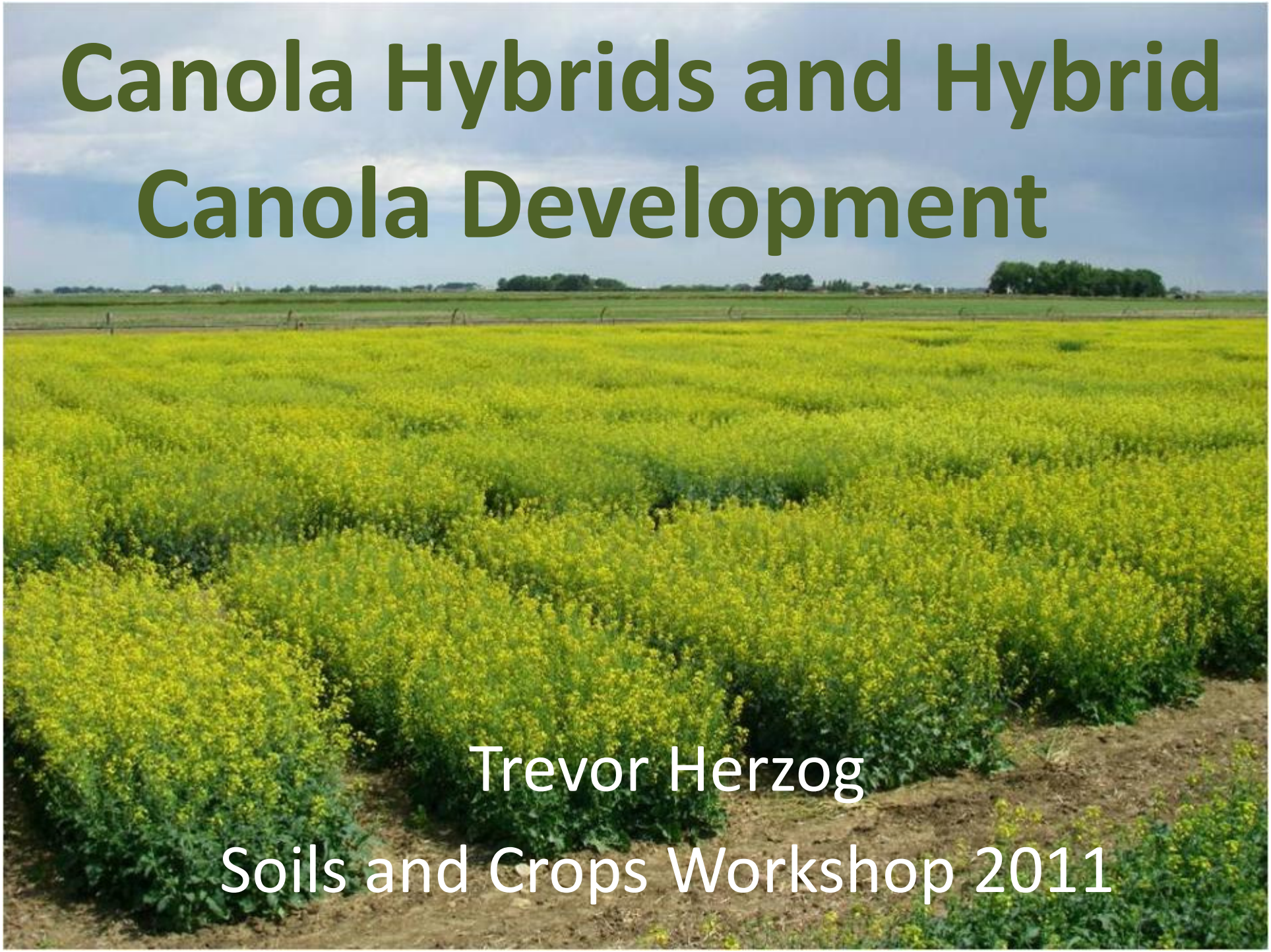
Canola Hybrids and Hybrid Canola Development



Trevor Herzog

Soils and Crops Workshop 2011

Agenda

- Canola Market
- Hybrid Systems Development
- New canola traits

Canadian Canola Production

Year	Acres (000's)	Tonnes (000's)	Yield (Bu/ac)
1986	6497.9	3713.8	25.2
1996	8527.4	5062.3	26.2
2000	12007.4	7205.3	26.5
2010	16097.4	11866.2	32.5

Note: 34.7 and 34.8 bu/ac achieved in 2008 and 2009 respectively

Source: Field Crop Reporting Series - Statistics Canada. Updated Dec 3, 2010

Canola Growing Great 2015

- Canola Council Goals set in 2007

Element	2006	2010	2015
Production (tonnes)	9 M	11.7 M	15 M
Acres	13 M	16.5 M	17 M
Yield (Bu/ac)	32	32.5	40.5
Export Crush (tonnes)	5.2 M	7.5 – 8 M	7.5 M
Domestic Crush (tonnes	3.7 M	7.6 M	7.5 M

2011 acres projected at 19 M x 35 bu/ac = 15 M tonnes

Source: Canola Council of Canada, 2007

What is a hybrid?

- Cross between a pure female inbred (A-line) and a pure male inbred (R-line).
  - The result is a heterozygous plant.

- Heterosis - 2+2 = 5 How can a hybrid out-yield either of it's parents? What is heterosis?
  - It is a phenomenon associated with ***genetic diversity***: the more diverse or different the parents are, in general, the bigger the heterotic effect (yield increases).

How do we make a Canola hybrid?

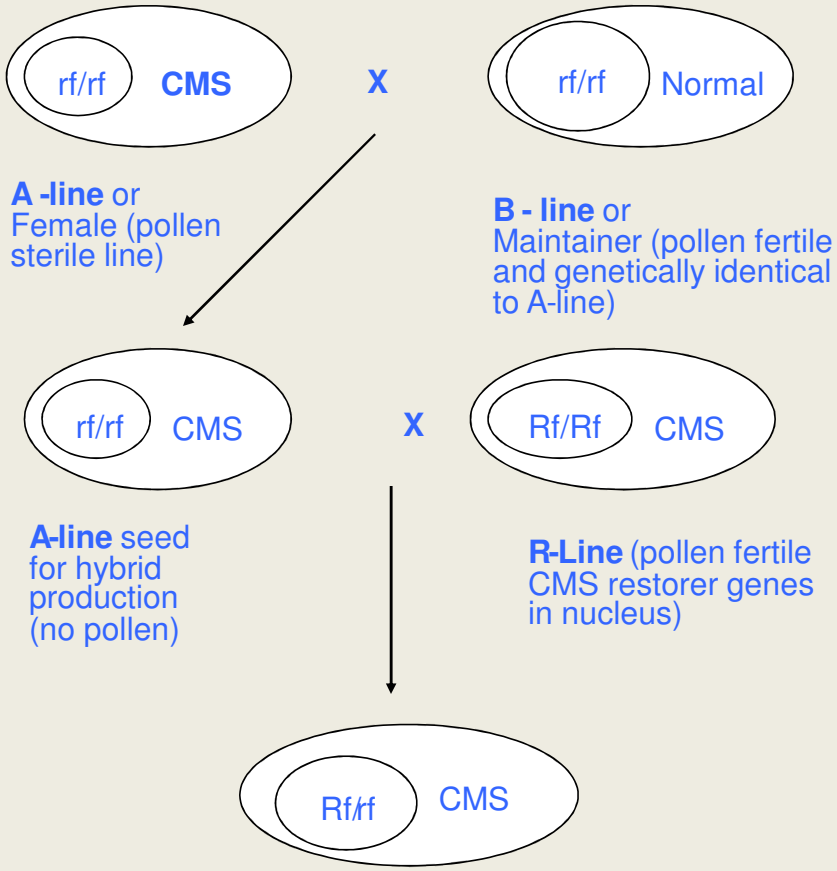
- Argentine canola (B. napus) typically is 75% self pollinated (canola plant pollinates itself) and 25% cross pollinated (another canola plant pollinates it).
- The challenge is to prevent one parent from pollinating itself so the seed produced is truly hybrid and not partially a self pollinated inbred.
- This is done using a pollination control system (fancy way of saying we stop one parent from producing pollen).
- The female plant is made sterile and crossed with a male plant that is fertile.

Cytoplasmic Male Sterility

- Some Brassica species have male-sterile cytoplasm (material around nucleus of cell)
- Fertility is controlled by interaction of cell nucleus with cytoplasm
- CMS in canola depends on this mutation to fail in developing functional pollen or anthers
- Produces females that either:
  - Fail to produce pollen
  - Fail to shed pollen
  - Make pollen that is unable to cause self fertilization
- System is composed of:
  - Male sterile line A
  - Maintainer line B
  - Restorer line R
- 1989 = Hyola 40 (Advanta Seeds)
- 1991 = Hyola 401 (Advanta Seeds)

CMS Hybrid Canola

Classic CMS System (Monsanto, Pioneer Hi-Bred)



CMS – Cytoplasmic male sterility

Rf – Restore fertility

A hybrid = Heterozygous plant (ie – Rr)

Plant Genetics Systems

- Developed through biotechnology
- Male sterile – gene isolated from soil bacterium causes nuclear male sterility. Controls production of specific enzyme in a specific anther cell layer at a specific stage of anther development = no pollen
- 2nd gene produces inhibitor enzyme to counteract sterility enzyme in first parent
- Gene for Liberty tolerance in both parents
- 1996 = 3850 and 3880 (Aventis)

PGS system (Seedlink ™) – University of Ghent 1989

First hybrids using this system were in 1995 COOP 2. PGS1 and PGS2 recommended for registration February 1996. Two transgenes involved.

Ms - barnase gene (specifically breaks down *tapetum*-> no pollen), linked to LL
Rf - barstar gene (dominant to and inhibits barnase activity), linked to LL

Sterile increase

(Ms ms) (ms ms) (Ms ms) (ms ms)

Field contains both steriles (MS ms) & fertiles (ms ms), planted in strips, males mowed out after flowering

Hybrid Production

(Ms ms) (ms ms) (Rf Rf) (Ms ms) (ms ms)

fertile plants sprayed out 2-4 leaf stage, otherwise contaminant

Disadv - production problems if incomplete kill
Advantage – two line system

New Canola Traits

Current Canadian Canola Production Challenges

Diseases

Sclerotinia, alternaria

Largely influenced by weather, climate, crop canopy

Blackleg

new, evolving races

Clubroot

Devastating disease currently prevalent in north-central Alberta near Edmonton

Photos: Canola Council of Canada

Current Canadian Canola Production Challenges

Insects

- Cabbage seedpod weevil, problem in southern Alberta, continuing move north and eastward,
- Flea beetles – especially striped flea beetles in Peace region and North-central AB, appear to be more tolerant of current seed treatment insecticides.
- Bertha armyworm –cyclic
- Cutworms/wireworms – spotty
- Monitoring for Swede Midge and Pollen beetle movement from eastern Canada

Future Canadian Canola Production Outcomes

Anticipated input traits under current research & development

- Improved disease and insect resistance/tolerance
- Improved fertilizer use efficiency, N & S
- Improved stress tolerance – frost, drought, heat, salinity
- Improved pod strength/architecture to allow for widespread straight cutting

Canola Trait Submissions and Field Trials

Table 1. Summary of approved submissions and field trials planted in Canada

Year	Number of Submissions	Number of Field Trials
2010	159	797
2009	157	818
2008	124	420
2007	96	349

Source: Canada Food Inspection Agency. www.inspection.gc.ca

Canola Trait Breeding Objectives

Table 2: Summary of 2010 field trials' breeding objectives.

Breeding Objectives	Year			
	2010	**2009**	**2008**	**2007**
Herbicide Tolerance	603	558	90	48
Stress Tolerance	143	385	71	6
Yield Increase	313	214	45	
Male Sterility	4	8	24	32
Modified Oil	5	7	9	20
Selectable Marker	33	99	96	
Fertility Restoration		6	24	
Nitrogen Use	82			
Water Use	50			
Other	4	1		145
Total	**649**	**661**	**163**	**209**

Source: Canada Food Inspection Agency. www.inspection.gc.ca

New Canola Traits

- Need to be in best germplasm
- Biotech vs non-biotech
  - Plant architecture
  - Shatter
  - Cost
  - Other?
- Companies are collaborating
  - New traits are expensive to deliver on
  - Need new technologies on lots of acres
  - Speed to market
  - Increased yields

Herbicide Tolerance

- Pioneer Hi-bred Research
  - Glyphosate Resistance
  - Phase 3 of R&D
    - 4 step phase
- Monsanto
  - Next Generation canola
    - Wider window of app.
    - Increased rate tolerance

Glyphosate Tolerance - Canola

PIONEER
A DuPont Business

Trait at a Glance

The goal of glyphosate-tolerant canola from Pioneer Hi-Bred is to enable in-crop use of glyphosate in canola at current label rates and growth stages for weed control. This would provide growers with the flexibility and effective weed control of glyphosate, with the high yield and strong agronomic performance of Pioneer genetics. Developed through exclusive gene shuffling technology, the glyphosate-tolerance trait would provide a superior option for broad-spectrum post-emergent weed control in canola.

- R&D Pipeline Phase: Phase 3, Advanced Development
- Primary & Opportunity Markets: North America, Europe, Asia Pacific
- Primary Market Acreage Opportunity: >70%

Grower Value at a Glance = **Harvestable Yield** + **Weed Control** + **Flexibility**

Anticipating Needs

Currently, 50 percent of canola acres in Canada and the U.S. are planted with products containing glyphosate-tolerance, and this is expected to increase significantly in the coming years. Growth in the use of glyphosate-tolerance will be driven by the convenience and effective weed control associated with this technology.

Pioneer's glyphosate tolerant canola would provide growers a superior option for broad-spectrum post-emergent weed control.

Delivering Solutions

The glyphosate tolerance trait will allow safe use of glyphosate on canola, combining effective broad-spectrum post-emergent weed control with the high yield and strong agronomic performance of Pioneer® brand canola hybrids. In addition, the trait will be stacked with industry-leading Pioneer Protector™ resistance to Sclerotinia and clubroot diseases.

Delivering Value

Testing will continue in 2011 and beyond to fully characterize this trait in various genetic backgrounds and environments, and label recommendations will be sought that maximize customer benefits and Pioneer trait differentiation.

Source: www.pioneer.com

Disease Resistance

- Clubroot:
  - Many varieties introduced to the market this past year:
    - Viterra
    - Pioneer Hi-bred
    - Dekalb
    - Canterra
  - Resistant Cultivar observations from 2010:
    - Susceptible Volunteers & off-types
    - Highly reduced symptoms NOT immune
    - Exposed to highest disease pressure
  - Companies continue to seek improvements

Resting spores of clubroot within host (canola) cells. This image was taken using scanning electron microscopy. [Photo courtesy of J.P. Tewari, University of Alberta]

Disease Resistance

- Sclerotinia:
  - Varieties on the market
    - Viterra
    - Pioneer Hi-bred
  - Most companies focused in this area
  - 2010 Disease Survey in Alberta
    - Sclerotinia stem rot found in **64% of fields surveyed**
    - Average incidence of 23% in infected fields
    - #1 rated canola disease in all Western Canada in 2010



Photos: Trevor Herzog, Monsanto Canada Inc.

Disease Resistance

- Blackleg
  - Additional Screening Required
    - Disease Complexity
      - Pathotypes continue to be on the rise
    - Regional Difference in Performance
      - 5 km away can change pathotypes
    - Public Coop Testing Sites
      - Contains a range of pathotypes
  - Canola Council of Canada
    - Engagement with the industry
    - Meeting to determine next steps
  - Best recommendation is to rotate canola varieties on the same field.

Photo: Canola Council of Canada

Insect Resistance

Cabbage Seed Pod Weevil

- U of A – type of canola that repels Cabbage seed pod weevil
- Incorporated white mustard species resistance developed by the University of Guelph

Photo: Canola Council of Canada

Flea Beetle Tolerance – Hairy Canola

- AAFC – type of canola that produces hairs to repel Flea beetles
- Objective to produce branched trichomes vs. single trichomes (hairs) from *Arabidopsis.*

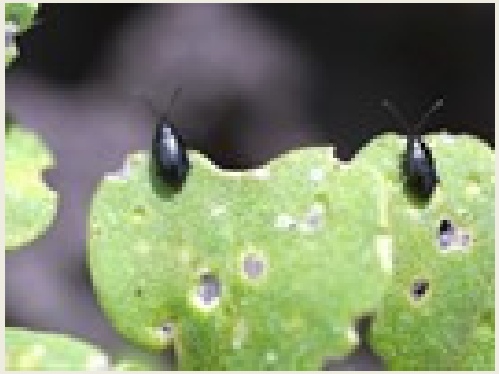
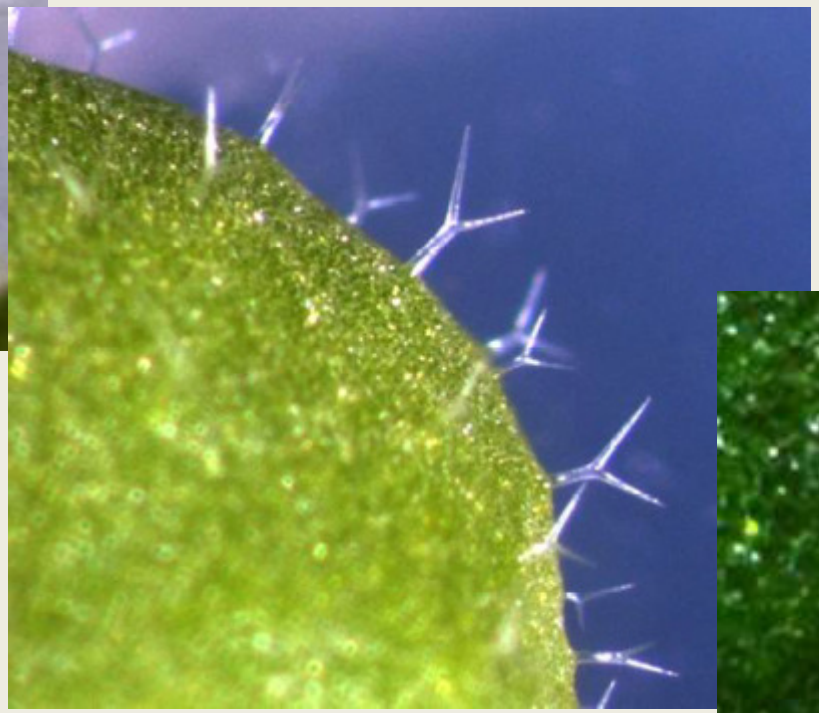


Photo: Canola Council of Canada

Single-branched mutant



Two-branched mutant

Six-branched mutant

Photos: Agriculture and Agri-Food Canada

Canola in the Future

- Other Related Research into the future and predictions:
  - Market Pace
    - 6 competitive companies
    - Contra Season Production
    - Canola Registration System changes
  - Collaborative Efforts
    - Partnerships within the industry
  - Stacking Traits
    - Which traits to combine?
    - Cost vs. reward?
  - End Use Quality Aspects
    - Higher Oil
    - Unique markets requesting specific traits & profiles
    - Canola Meal quality

Conclusion

- Forty+ years of breeding and biotechnology have created a major crop for Canada and Europe (Canola/OSR)
- Many different techniques and tools were applied to achieve success: Conventional Breeding, Mutation Breeding, Inter-specific crosses, Genetic Engineering, Molecular markers, Di-haploid Breeding, etc.
- Collaborative efforts
- Canola……..Growing Great 2015!!

Questions, comments?